COMMERCIAL FISHERIES

STATE OF THE GULF OF MAINE REPORT

Gulf of Maine
Council on the
Marine Environment

November 2013

COMMERCIAL FISHERIES

STATE OF THE GULF OF MAINE REPORT

TABLE OF CONTENTS

Gulf of Maine Council on the Marine Environment

Fisheries and Oceans Canada | Pêches et Océans Canada

This publication was made possible through the support of the Gulf of Maine Council on the Marine Environment and funding from Fisheries and Oceans Canada.

The Gulf of Maine Council on the Marine Environment was established in 1989 by the Governments of Nova Scotia, New Brunswick, Maine, New Hampshire and Massachusetts to foster cooperative actions within the Gulf watershed. Its mission is to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations.

Photo credits: yellowtail flounder (p. 7) courtesy of NOAA; Atlantic herring (p. 9) used with permission of Lori Steele; lobster boats (p. 11) and scallops (p. 13) used with permission of Trisha DeGraaf; tunas (p. 15) used with permission of Ben Weiner.

Cover photo: © Peter Taylor/Waterview Consulting

Cover map (background): Courtesy of Census of Marine Life/ Gulf of Maine Area Program

CONTRIBUTORS

AUTHOR:

George Lapointe
Fisheries Consultant
Hallowell, Maine

DESIGN AND LAYOUT:

Waterview Consulting (www.waterviewconsulting.com)

1. Issue in Brief

Commercial fisheries have a long history in the Gulf of Maine (Figure 1), beginning with the cod and haddock fishery that was established prior to colonization of North America by Europeans (Kurlansky 1997).[1] Various commercial fisheries developed in the region during early European colonization of North America and have remained economically and socially important. In 2009, commercial fisheries in the Gulf of Maine landed 505 thousand metric tons (mt)[2] of seafood with a dockside value of $114.5 million[3] (NMFS 2010, DFO landings data). These fisheries are dynamic, with the relative dominance of species changing over time in response to fishing pressure, environmental conditions, and unknown factors.

LINKAGES

This theme paper also links to the following theme papers:

- Climate Change and Its Effects on Ecosystems, Habitats and Biota
- Climate Change and Its Effects on Humans
- Species at Risk
- Invasive Species
- Coastal Land Use and Development

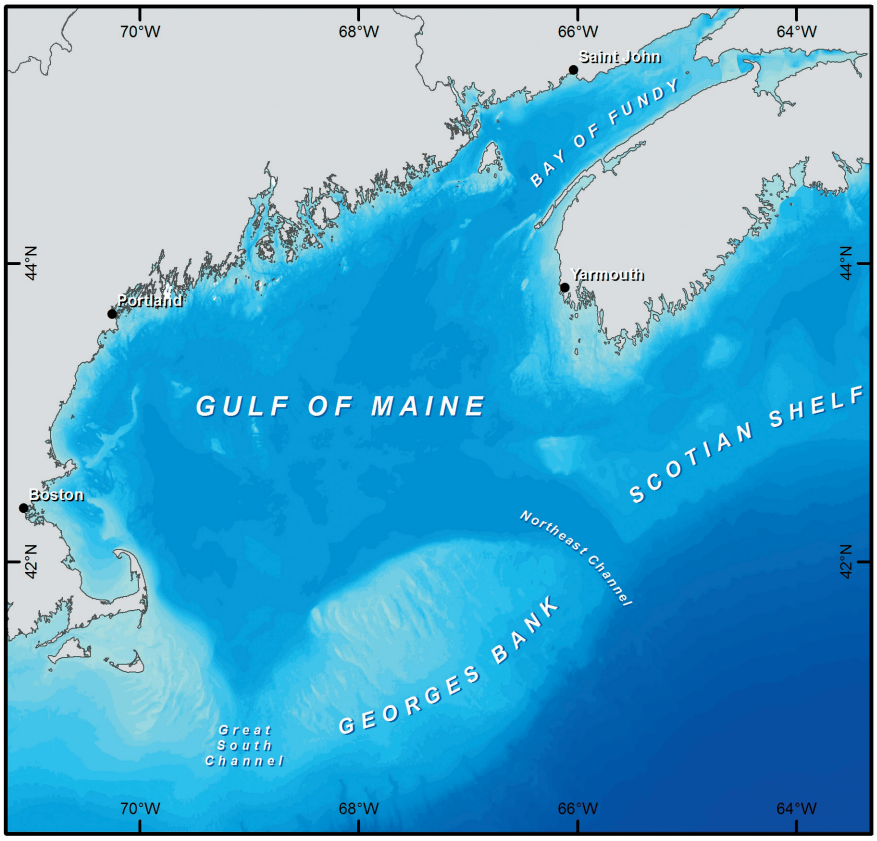


Figure 1: The Gulf of Maine.

[1] The Gulf of Maine area includes the Bay of Fundy, the Northeast Channel and Georges Bank. It is bounded to the northeast by the Scotian Shelf and is separated from the waters to the southwest (i.e., southern New England) by Georges Bank.

[2] 1 metric ton (mt) = 1000 kilograms (kg) = 2204 pounds.

[3] All dollar amounts in U.S. dollars, converted based on average annual exchange rate (Bank of Canada 2013).

Figure 2 diagrams the driving forces, pressures, states, impacts, and responses (DPSIR) on Gulf of Maine commercial fisheries. Driving forces that affect the region's commercial fisheries include market demand for fishery products, regional and global socioeconomic conditions, human population growth, and climate change. The long-term health of Gulf of Maine fisheries is affected by many pressures including fishing, availability of working waterfront, variations in the ocean environment, and habitat changes. These pressures have resulted in some fish populations being reduced to levels that make it difficult for fish harvesters to make a profit, reduced biological productivity, and in extreme situations, threatened population viability. Environmental changes (including increased coastal nutrient enrichment, increased ocean temperature, and ocean acidification) will likely cause shifts in abundance and distribution of commercial fish species and reduced growth and survival (see Eutrophication theme paper and Climate Change and its Effects on Ecosystems, Habitats and Biota theme paper). These changes will likely have significant consequences in terms of the productivity and economics of the region's commercial fisheries through diminished availability of fish and management constraints.

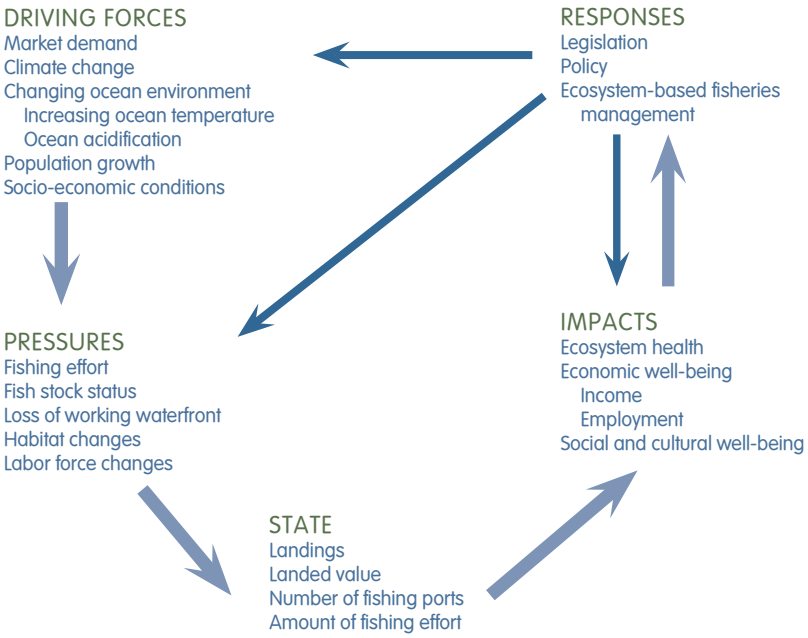


Figure 2: Driving forces, pressures, state, impacts, and responses (DPSIR) for commercial fisheries in the Gulf of Maine. The DPSIR framework depicts the relationship among human activities and the environment. Anthropogenic and natural driving forces cause pressures that affect commercial fisheries through landings, value, and distribution. The subsequent impacts on ecosystem health, employment, income, economic contribution to the region's economy, and sense of social and cultural well-being lead to responses in the form of regulations, laws, and agreements to adapt to evolving ecological, economic, and cultural needs.

2. Driving Forces and Pressures

Driving forces are broad-scale human-caused and natural forces impacting, in this case, commercial fisheries. The driving forces cause pressures that affect commercial fisheries through landings, value, and distribution.

2.1 POPULATION GROWTH

Population growth in Canada, the United States, and the world have caused, and will continue to cause, direct and indirect pressures on Gulf of Maine commercial fisheries. The population of Canada is expected to increase from 35 million to 42.5 million by 2056 (Statistics Canada 2008; Statistics Canada 2013) and the population of the United States is projected to increase from 315.6 million to 399 million by 2050 (Ortman and Guarneri 2012; US Census 2013). The population of the world is projected to increase from the 7.07 billion to 8.99 billion by 2050 (United Nations 2004; US Census 2013). As human population grows, so too will the regional and global demand for food and other natural resources.

A disproportionate amount of population growth occurs in coastal areas, which puts additional pressure on coastal resources and nearshore and offshore fisheries. For example, 53 percent of the U.S. population lives in the coastal zone, which comprises only 17 percent of U.S. land area (NOAA 2013). Indirect effects of urban, residential, and agricultural development of coastal watersheds associated with burgeoning populations will cause continued degradation of nearshore and marine ecosystems (see Coastal Land Use and Development theme paper).

2.2 SEAFOOD DEMAND AND MARKET FORCES

Population growth in Canada, the United States, and the world has resulted in increased demand for fish products from the sea. As a result of projected increased demand, worldwide fisheries and aquaculture production is expected to increase 15 percent over 2009-2011 levels, reaching approximately 170 million mt in 2021 (OECD-FAO 2012). The increased demand for fish is expected to come with higher prices and production costs and an increasing globalized supply chain, with 34 percent of worldwide fishery production being exported to other countries (OECD-FAO 2012).

For Gulf of Maine commercial fisheries, global markets and demands will exert a significant and growing impact on the region's fishery resources and fisheries supply chains. Increased pressure on fishery resources will require timely management responses to restore, as needed, and maintain resource sustainability. Additionally, the bilateral trade between Canada and the United States is strong and will also exert pressure on Gulf of Maine resources. In 2010, the United States imported 304 thousand mt of seafood with a value of $2.31 billion from Canada

and exported to Canada 155 thousand mt valued at $958.3 million (NMFS 2011). In 2010, seafood exports from Canada to the United States accounted for 52 percent of Canada's seafood exports (DFO 2013a). Canadian seafood imports from the United States made up 36 percent of the total seafood imported with British Columbia, Ontario, New Brunswick, and Quebec the largest Canadian import markets (DFO 2013a). Economic difficulties in traditional U.S. and European markets post-2008 have led to the increasing importance of non-traditional markets, such as China.

In addition to traditional regional and global markets for Canadian and U.S. seafood, there is a growing interest in eating locally raised or caught products, and community supported fisheries (CSFs) may exert a larger influence on local markets and economic return to harvesters in the Gulf of Maine region. The CSF market currently handles a very small proportion of the seafood caught in the Gulf of Maine. However, an indication of the interest and growth in CSFs is the National Summit on Community Supported Fisheries held in 2012, which produced a CSF handbook (NSGLC 2012). There were eight CSFs in the Gulf of Maine region in 2012 (NAMA 2012) and as support for local commercial fisheries grows, establishment of more CSFs can be expected.

2.3 SOCIO-ECONOMIC CONDITIONS

Commercial fishing has been a part of the historic fabric of the Gulf of Maine region for over 400 years (Kurlansky 1997) with the groundfish fishery being the dominant early component. Ports such as Gloucester, Massachusetts; Portsmouth, New Hampshire; Portland, Maine; and Yarmouth, Nova Scotia grew in part to support the fishing industry. Salt cod was an important export product in the United States and Canada, providing currency for foreign trade (Kurlansky 1997).

Over time and as other fisheries developed, federal, state, and provincial governments responded to develop and manage the Gulf of Maine's abundant fishery resources. The importance and economic value of individual fisheries have fluctuated as species abundance and market demand have changed over time. Species such as cod and haddock were the foundation of the Gulf of Maine fishing industry. This has changed fairly recently, since the 1970s or 1980s, with declines in groundfish abundance and changing fishery management measures. The lobster and scallop fisheries have increased significantly since the 1980s, becoming very important to the region. Another example of shifting patterns in Gulf of Maine fisheries is the sardine industry. At its peak in the 1950s, there were over 50 canneries that provided jobs and economic activity to individuals and communities throughout the Gulf of Maine region; by 2010 this number had decreased to one cannery in New Brunswick. The lobster fishery developed early as a fishery throughout the Gulf of Maine that provided economic opportunity to many people. However, the historic lobster fishery landed a fraction of what is currently

being taken from the Gulf of Maine. The sea urchin fishery is a recent example of "boom and bust" fisheries, in which the fishery expanded very rapidly in the 1980s and then declined very rapidly because of resource depletion. Other fisheries, such as river herring, salmon, and sturgeon, were impacted by overharvest and habitat and environmental changes.

Up until the 1970s in Canada and 1980s and 1990s in the United States, Gulf of Maine commercial fisheries were largely open access, i.e., available to anyone who wanted to enter the fishery, with limited regulations. In contrast, today many fisheries are managed with limited access provisions and other regulations to ensure long-term resource sustainability and economic value. These regulatory changes have fundamentally altered commercial fishing in the Gulf of Maine. In the past, fish harvesters would switch among fisheries based on season, price, and resource availability. Limited entry in many fisheries has reduced fish harvesters' ability to switch among fisheries, resulting in reliance on fewer fisheries and vulnerability to price and resource variability. One response to limited access programs by harvesters is to retain licenses in multiple fisheries which allows them to adapt to changing market conditions and abundance in individual fisheries.

Throughout the regulatory, economic, cultural, and ecosystem changes that have occurred over the past 400 years, commercial fisheries have remained an important part of the social and economic fabric in the Gulf of Maine region, supporting thousands of jobs and families and contributing billions of dollars to the regional economy. Gulf of Maine fisheries are also iconic symbols that draw worldwide attention to the region.

2.4 CLIMATE CHANGE AND ECOSYSTEM INFLUENCES

Climate change will impact the Gulf of Maine area in many ways, including increasing sea level, increasing ocean temperature, ocean acidification, shifts in ocean currents, and altered abundance and distribution of plants and animals (Fogarty et al. 2007; Frumhoff et al. 2007; Schmitt 2011; see Climate Change and its Effects on Ecosystems, Habitats and Biota). System-wide impacts of climate change will be complex and may occur in unforeseen ways. For example, Fogarty et al. (2008) hypothesized that warm waters will cause cod populations to decline and lobster to decline in southern areas and potentially increase in more northern areas. In addition, blue crabs may become commercially exploitable in southern New England. Species at the southern limit of their range, such as northern shrimp (DFO 2012a; Richards et al. 2012) and Atlantic salmon, could decline or become locally extinct, commercially or biologically, from the Gulf of Maine. The movement of species historically associated with the mid-Atlantic into the Gulf of Maine, such as summer flounder, scup, and black sea bass, is also being observed in the Gulf of Maine. Ocean acidification could have very significant negative impacts on the lobster and clam fisheries through the effects of changes in

calcium carbonate availability in the environment which, in turn, can impact shell development and strength (Curran and Azetsu-Scott 2012). Fishery management agencies will need to monitor impacts of climate change very closely and adapt management strategies to provide for sustainable commercial fisheries under changing and unpredictable ecosystem conditions.

Another ecosystem influence impacting the Gulf of Maine is the addition of new, invasive species which also impact the region's commercial fisheries. For example, the prevalence of green crabs and Asian shore crabs has caused reduced abundance of soft-shelled clams, sea urchins, and eels (Thayer and Stahlnecker 2006; DFO 2009). Other organisms such as invasive tunicates could potentially disrupt fisheries in the Gulf of Maine by impacting native habitat conditions (LeGresley et al. 2008).

3. Status and Trends

The Gulf of Maine region is home to a diverse commercial fishing industry that provides socio-economic benefits and well-being to many fish harvesters and communities. Some of these fisheries are valued in the millions of dollars, whereas others have much lower volume or individual value. Many fish harvesters make their living by participating in more than one fishery, making each fishery important to the region. The diversity of commercial fisheries in the Gulf of Maine is shown in Table 1, which lists all fisheries with recorded landings regardless of volume.[4]

3.1 MAJOR FISHERIES

Major fisheries in the Gulf of Maine include groundfish, herring, lobster, scallop, soft-shell clam, and tuna. These fisheries have long histories of contributing socially and economically to the region. The volume and value of these fisheries have varied through time with resource abundance, fishing pressure, and market demand, but some major trends are evident. A general characteristic of these fisheries is that they are dynamic, changing with variations in species abundance and distribution, market demand, vessels, gear, and regulations.

Groundfish

The groundfish fishery includes the catch of cod, haddock, pollock, hake, Acadian redfish, and a number of flounder species that are caught on or near the ocean floor (see box). This fishery was a founding industry in the Gulf of Maine, starting before European colonization. The early groundfish fishery was conducted with hook and line from small boats. These boats fished out of local harbors or were launched from larger sailing vessels to fish on offshore banks of shallow, productive waters. New gears were added to the fishery as technology changed from hooks to fish traps, gillnets, and otter trawls (FRCC 2011).

Historical landings of groundfish in the Gulf of Maine region are hard to compare with current landings because of poor historical reporting, different data sources, and different reporting areas. However, it is clear that landings in the past were very high relative to current levels, because of high fish abundance and a large number of vessels pursuing groundfish stocks (Figure 3). For example, cod catch on Georges Bank was estimated at greater than 60 thousand mt in the late 1890s (Serchuk et al. 1994), groundfish landings in the United States were estimated at 760 thousand mt in 1965 (NMFS 1999), and cod landings in the northwest

Species in Gulf of Maine Groundfish Fishery

- American plaice[a,b]
- Atlantic cod[a,b]
- Atlantic halibut[a,b]
- Haddock[a,b]
- Ocean pout[a,b]
- Offshore hake[a,b]
- Pollock[a,b]
- Red hake[b]
- Redfish[a,b]
- Silver hake[b]
- White hake[b]
- Windowpane flounder[a,b]
- Winter flounder[a,b]
- Witch flounder[a,b]
- Yellowtail flounder[a,b]
- Monkfish[a]

[a] Canada
[b] U.S.

[4] Statistics on species landed in New Brunswick and Nova Scotia from NAFO areas 4XP, 4XQ, 4XR, 4XS, 5YB, 5YC, 5YF, 5ZEH and 5ZEJ. Statistics on species landed in Maine, New Hampshire, and Massachusetts from NAFO areas 4X, 5Y and 5ZE.

Table 1: Commercial fisheries by Gulf of Maine Jurisdiction (Sources: DFO landings data, MEDMR landings data, NHDFG landings data, MADMF landings data).

FISHERY (SCIENTIFIC NAME(S) OF SPECIES)	JURISDICTION				
	NOVA SCOTIA	NEW BRUNSWICK	MAINE	NEW HAMPSHIRE	MASSACHUSETTS
Diadromous					
Alewife *(Alosa pseudoharengus, Alosa aestivalis)*	X	X	X	X	
Eel, adult *(Anguilla rostrata)*	X		X		X
Glass/elver *(Anguilla rostrata)*	X	X	X		
Smelt *(Osmerus mordax)*	X		X	X	X
Pelagic					
Bluefish *(Pomatomus saltatrix)*				X	X
Herring *(Clupea harengus)*	X	X	X	X	X
Mackerel *(Scomber scombrus)*	X	X	X	X	X
Menhaden *(Brevoortia tyrannus)*			X	X	
Sharks (Galeomorphii)	X	X	X	X	X
Swordfish *(Xiphias gladius)*	X	X	X	X	X
Tunas *(Thunnus* sp.*)*	X	X	X	X	X
Demersal					
Dogfish *(Squalus acanthias)*	X	X	X	X	X
Groundfish*	X	X	X	X	X
Monkfish *(Lophius americanus)*	X	X	X	X	X
Skates (Family Rajidae)	X	X		X	X
Hagfish *(Myxine glutinosa)*	X	X	X		X
Invertebrates					
Bloodworm *(Glycera sp.)*	X	X	X		X
Clam, soft-shell *(Mya arenaria)*	X	X	X		X
Clam, hard *(Mercenaria mercenaria)*	X	X	X		X
Clam, mahogany *(Arctica islandica)*	X	X	X		
Crab, rock *(Cancer irroratus)*, Jonah *(C. borealis)*, Snow *(Chionoecetes opilio)*	X	X	X	X	X
Crab, red *(Chaccon quinquedens)*			X		X
Lobster *(Homarus americanus)*	X	X	X	X	X
Oyster *(Ostrea spp.)*			X		X
Periwinkle *(Littorina sp.)*	X	X	X		
Sandworm *(Alitta sp.)*	X	X	X		X
Scallop *(Plactopecten magellanicus)*	X	X	X	X	X
Sea Cucumber *(Cucumaria frondosa)*	X	X	X		
Sea Urchin *(Strongylocentrotus droebachiensis)*	X	X	X		
Northern shrimp, *(Pandalus borealis)*	X	X	X	X	X
Squid *(Illex illecebrosus, Doryteuthis pealeii)*	X	X			X
Marine Plants	X	X	X		X

* Groundfish includes American plaice *(Hippoglossoides platessoides)*, Atlantic cod *(Gadus morhua)*, Atlantic halibut *(Hippoglossus hippoglossus)*, haddock *(Melanogrammus aeglefinus)*, ocean pout *(Zoarces americanus)*, offshore hake *(Merluccius albidus)*, pollock *(Pollachius virens)*, red hake *(Urophycis chuss)*, redfish *(Sebastes fasciatus)*, silver hake *(Merluccius bilinearis)*, white hake *(Urophycis tenuis)*, winter flounder *(Pseudoplueronectes americanus)*, witch flounder *(Glyptocephalus cynoglossus)*, and yellowtail flounder *(Limanda ferruginea)*.

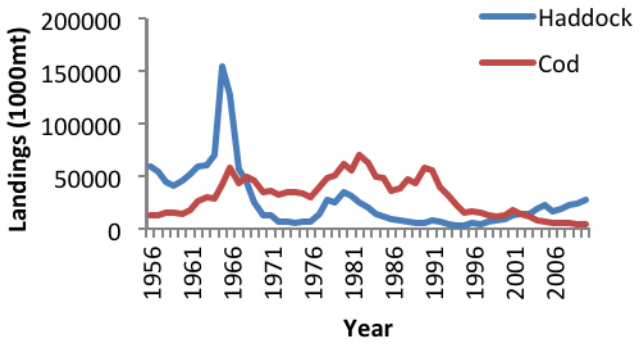


Figure 3: Cod and haddock landings, 1956-2010 (Source: Brodziak and Traver 2006; Mayo and O'Brien 2006; NEFSC 2008, 2012; Wang and O'Brien 2012; DFO landings data).

Atlantic were almost 2 million mt in the 1960s (DFO 2013b). Current catch levels are much lower because of reduced abundance and subsequent management restrictions. Other groundfish species show similar fishery trends of high landings followed by reduced abundance and landings (Sosebee et al. 2006).

Management of the groundfish fishery currently combines gear, area, and catch restrictions through quotas or allowable catch levels (DFO 2003; DFO 2008b; NEFMC 2009). The status of many groundfish stocks combined with the multi-species nature of the fishery has resulted in an extended period of conservative management actions with the goal of constraining catch to sustainable levels. This has resulted in fewer vessels, fewer participants, and fewer ports landing groundfish than in the past (Kitts et al. 2011). Quotas for some species or stocks is constrained to very low levels that impact the ability of the overall fishery to catch quotas of more abundant species as in the case of Eastern Georges Bank haddock catch being limited by very low cod quotas (TRAC 2012a). In the United States, stocks with very low quotas ("choke stocks") that limit catch of other more abundant stocks and overall low total allowable catch levels resulted in a fishery disaster declaration in 2012 for the U.S. northeast groundfish fishery (NMFS 2012a) because of cumulative impacts to the New England fishing industry and communities.

Atlantic Herring

The Atlantic herring is an economically and ecologically important fish in the Gulf of Maine. Herring are preyed upon by nearly all ocean predators, including fish, birds, and mammals, and their abundance and schooling behavior make them important to many predators (Collette and Klein-MacPhee 2002). Herring were caught by indigenous people prior to European colonization and were used as bait in the pre-colonial cod fishery (Collette and Klein-MacPhee 2002). The more recent history of the fishery has

been a succession of catch by fixed gear (weirs and stop seines), purse seines, and then mid-water trawls (using single and pair trawls).

Herring has been used as a food source (sardines and pickled, smoked, salted, and frozen herring), as bait, and as fish meal. The sardine industry in Maine and the Bay of Fundy consisted of over 50 packing plants at its peak in the 1950s when over 3 million cases were packed annually. Demand for sardines declined with the availability of refrigeration, freezers, and efficient transportation for fresh fish. The last sardine cannery in the Gulf of Maine operates from Blacks Harbour, New Brunswick. Herring is currently used as a food fish, primarily for export, as bait in other fisheries, and as a component in aquaculture feed products. The demand for herring as bait has risen significantly with the increase in lobster catch in the Gulf of Maine since the 1980s. Currently, an estimated 70 percent of the Gulf of Maine herring catch is used as lobster bait (Grabowski et al. 2010).

Historically, herring were fished from inshore waters of the Gulf of Maine. In the early 1960s, an offshore fishery dominated by distant-water vessels developed, with landings peaking at 376 thousand mt in 1968 (Figure 4). This declined rapidly with a collapse in the fishery caused by overfishing (Overholz 2006). Gulf of Maine landings varied from 35 thousand mt to 125 thousand mt from 1980 to 2004 (Figure 4), and averaged 125 thousand mt from 2005 to 2010.

The herring fishery is managed under three separate management plans in the Gulf of Maine. State-water fisheries in the United States are managed under the Interstate Fishery Management Plan for Atlantic Herring by the Atlantic States Marine Fisheries Commission (ASMFC 2006), which prohibits herring from being used for fish meal, and protects spawning herring through time and area closures. Herring in U.S. federal waters are managed under the Fishery

Figure 4: Gulf of Maine Atlantic herring landings, 1960-2005 (Source: Overholz 2006; DFO landings data).

Management Plan for Atlantic Herring by the New England Fishery Management Council, which established limited access to the fishery, an area in the inshore Gulf of Maine for seasonal purse seine and fixed gear only, and a process for setting three-year quotas (NEFMC 2007). The herring fishery in the Bay of Fundy is managed by quota, with 80 percent of the quota allocated to the purse seine fleet and 20 percent allocated to gillnets and weirs (DFO 2004).

Lobster

Lobsters symbolize the entire Gulf of Maine, with lobster fishing taking place out of almost every harbor from Cape Cod to Nova Scotia. The vast majority of the fishery in the United States, and all of the Canadian fishery, is a pot fishery, consisting primarily of vessels under 50 feet (15 meters) fishing up to 800 traps in the United States (ASMFC 1997) and up to 375 traps in Canadian portions of the Gulf of Maine (DFO 2011). Historically, lobsters were caught from sailing vessels fishing wooden traps. These catch methods and the relatively short distance that live product could be shipped restricted the demand for lobster to regional live markets and processing by canning. These inefficiencies and stock conditions limited lobster catch in the region to an average of 13 thousand mt from 1900 to 1990. Lobster gear, processing and shipping technologies, and resource abundance have changed significantly and, since 1990, catches have increased substantially, reaching 90 thousand mt in the Gulf of Maine region in 2011 (Figure 5). A portion of this increase is due to increased efficiency in the fishery through better vessels, traps, and other gear (ASMFC 1996), but overall productivity in the lobster population has also increased over past levels. Many hypotheses have been proposed to explain the increase including reduced predation from groundfish, conservation measures in the fishery,

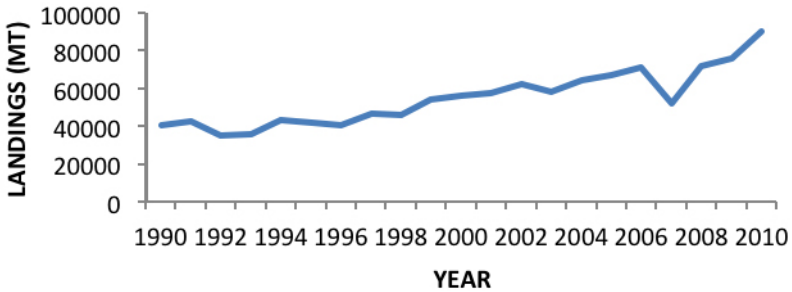


Figure 5: Gulf of Maine lobster landings, 1990-2011 (Source: DFO landings data; ACCSP data).

feeding lobsters with bait, and changing environmental conditions, but no single factor has been identified for the overall increase (ASMFC 1996).

The increases in catch and effort have not resulted in an overfished fishery as might be expected from experience in other fisheries. Recent Gulf of Maine lobster stock assessments indicate high catch rates, abundance, and effort in the fishery (Pezzack 2006; ASMFC 2009). High levels of fishing effort in the fishery are identified as an ongoing risk to Gulf of Maine lobster stocks in these assessments.

The increase in lobster landings in the Gulf of Maine since 1990 has resulted in significant economic activity in the industry and coastal communities, and high revenues for some harvesters. However, the increase has come with economic, market, and supply chain stresses. In addition to the large overall catch, in recent years a larger percentage of the yearly catch has been "soft-shell," or recently molted, lobsters, particularly in the United States and parts of the Bay of Fundy in Canada. These have combined to produce market gluts and decrease prices paid to lobster harvesters as the industry and market struggle to adapt to these changes. For example, the average price per pound paid to lobster harvesters in Maine in 2012 was $2.68, as compared to $4.00 in 2004 (MEDMR 2013). The larger quantity of soft-shell lobsters caught in summer and fall in the United States, primarily Maine, is shipped mainly to New Brunswick and Nova Scotia, which subsequently impacts lobster price in the provinces. This is a concern for harvesters in Canada. In 2012, the situation elevated into conflict, with U.S. trucks being blocked from crossing into Canada and talk of further action if the situation did not improve by the beginning of the lobster harvest season in Canada (CBC 2012). An agreement was reached to reduce tensions and resume cross-border lobster shipments (AP 2012), but the conflict indicates the volatility that can occur in fisheries.

Lobster management measures consist of trap limits, limited entry, marking (v-notching) and protection of egg bearing females, escape panels in traps, minimum size limits, maximum sizes in the United States, and seasons in Canadian waters of the Gulf of Maine (ASMFC 1997; DFO 2011a). The differences in management measures used in the two countries have resulted in tension between lobster harvesters from Canada and the United States. Lobster harvesters from both nations fish in a small area around Machias Seal Island because of an ongoing border dispute between the United States and Canada (Figure 6). This has resulted in some conflicts among lobster harvesters in the area because of differing management provisions in the United States and Canada and perceptions of unfairness on both sides of the border.

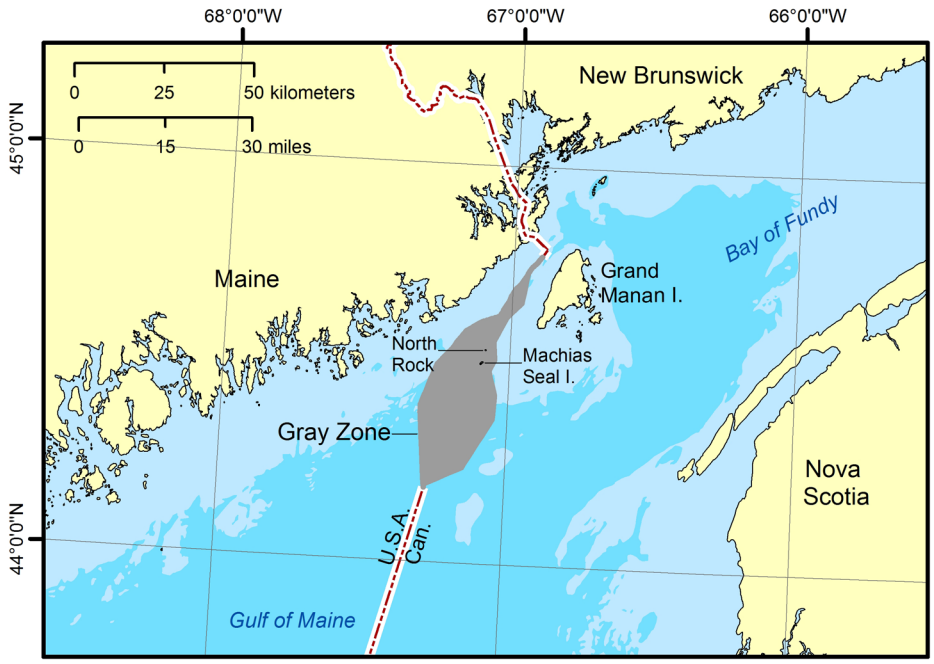


Figure 6: Area (gray zone) disputed between Canada and the United States (prepared by Oceans and Coastal Management Division, DFO).

Sea Scallop

The sea scallop fishery consists of a dredge or drag fishery in offshore and inshore areas and a dive fishery inshore in the United States. Dredges scrape scallops from the ocean floor; the scallops are then shucked, or cut open, to take the adductor muscle that is the edible portion of the scallop. There is growing interest in a whole scallop product.

The Canadian inshore scallop fishery in the Gulf of Maine/ Bay of Fundy is centered in Digby, Nova Scotia, where the bulk of scallops from the Canadian portion of the Gulf of Maine are landed. The Bay of Fundy scallop fishery is divided into Scallop Production Areas and Scallop Fishing Areas for stock assessment and management. The Bay of Fundy fishery is managed through a total allowable catch (TAC) which is accessed by Full Bay, Mid-Bay, and Upper Bay fleets, subarea quotas, meat count, and minimum shell height (DFO 2013c). The Full Bay TAC is allocated by percentage shares per license; Mid-Bay and Upper Bay fleets have a TAC that is fished competitively. The Canadian offshore fleet fishes Canada's offshore portions of the Gulf of Maine, including Georges Bank. The offshore fleet is managed with an enterprise allocation where each company receives a percentage share of the annual TAC for each scallop fishing area (DFO 2000).

The U.S. scallop fishery in the Gulf of Maine is centered on Georges Bank and is managed through an overall annual quota, limits on number of days fished, limits on permits, gear restrictions, and closed areas (NEFMC 2013). The U.S. fleet fishes both Georges Bank and the Mid-Atlantic States depending on area closures, quantity of scallops available, and proximity to ports. An in-state fishery in Maine is managed through rotational closed areas, gear restrictions, and dredge ring size limits (MEDMR 2012).

Total landings for the Gulf of Maine have varied widely since 1960 (Figure 7). The bulk of landings are harvested from Georges Bank and a much smaller proportion from the inshore portions of the Gulf of Maine.

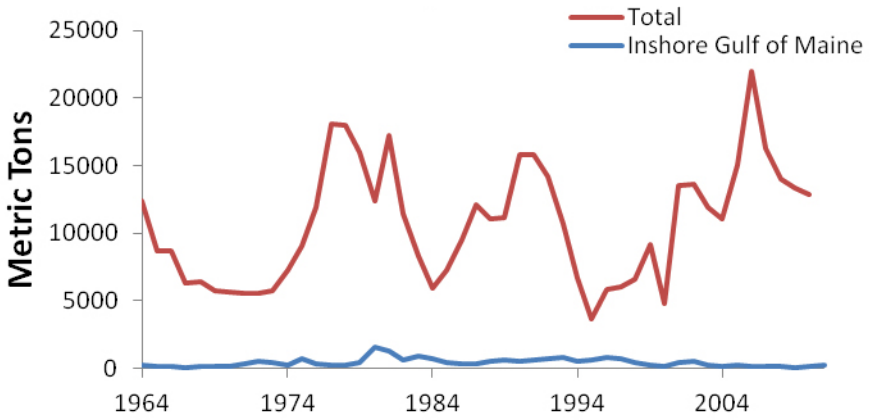


Figure 7: Gulf of Maine, inshore Gulf of Maine scallop landings, 1960–2010 (Source: Hart 2006; DFO landings data; state data).

Soft-shell Clam

Soft-shell clams are harvested from the intertidal zone throughout the Gulf of Maine by hand-digging with a clam rake, and are sold largely as fresh product (steamers). The clam fishery is managed in U.S. portions of the Gulf of Maine with state statutes and municipal management of catch limits, closed areas, closed time periods, and limits on the number of harvesters. Many municipalities also engage in population replenishment through planting small clams and trying to protect them from predation. States participate in clam management through state-wide measures to promote sustainability (e.g., minimum size limits) and to protect public health from bacterial and biotoxin contamination (see Microbial Pathogens and Toxins theme paper).

The soft-shell clam fishery can be significantly impacted by closure of shellfish harvest areas for bacterial pollution, as measured by coliform bacteria, and harmful algal bloom, such as red tides. Bacteria occur naturally but can be enhanced to unhealthy levels by coastal pollution and runoff. Biotoxin events from harmful algal blooms can occur throughout the year, but are associated with warmer

waters and onshore winds. Public health authorities in Canada and in the United States manage extensive testing programs and area closures to ensure that soft-shell clams and other shellfish sold to dealers and consumers are safe for consumption. Closures of shellfish harvest areas can be lengthy and geographically broad, which significantly impacts harvesters and others in the clam fishery, as well as consumers. Additionally, the future harvest of soft-shell clams may be impacted by increased frequency of harmful algal bloom closures associated with climate change (NCCOS 2011).

The soft-shell clam resource and fishery can be impacted by predation by crustaceans, marine worms, mollusks, fish, and birds (Beal 2000). Soft-shell clams have evolved with native predators but are also impacted by invasive species. The prevalence of green crabs and Asian shore crabs has had significant impacts on local clam populations at various times. Soft-shell clams in the Gulf of Maine will likely be impacted by other species (e.g., blue crabs) as increasing ocean temperatures alter species distributions.

Soft-shell clam landings vary significantly in the Gulf of Maine (Figure 8) based on resource abundance and public health closures.

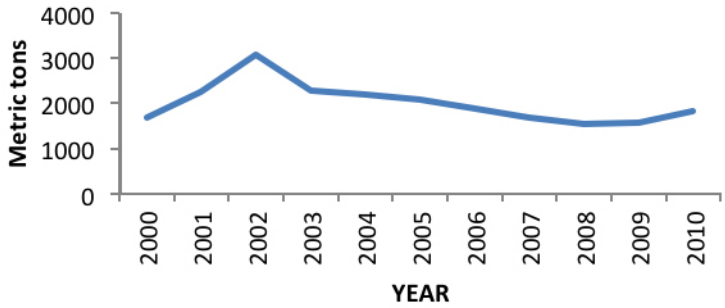


Figure 8: Reported Gulf of Maine soft-shell clam landings, 2000-2010 (Source: DFO landings data; ACCSP landings data).

Tuna

The tuna fishery in the Gulf of Maine consists of bluefin, albacore, bigeye, and yellowfin tuna, but the bluefin is the primary species because of abundance and price. Bluefin tuna is a widely distributed, valuable commercial species throughout the Gulf of Maine. Tuna are sold domestically for sushi and for cooking. They are also very valuable in the Japanese fish market where a single tuna was recently sold for $1.76 million (Revkin 2013). The high price for tuna has led to a significant fishery in the Gulf

of Maine and elsewhere, and concerns about worldwide population sustainability have been expressed.

Bluefin tuna are assessed and managed through an international treaty organization, the International Convention for the Conservation of Atlantic Tuna (ICCAT), because the bluefin tuna's widespread distribution and extensive migrations necessitates coordinated international conservation and management. The directed bluefin tuna fishery in Canada uses hook and line gear or tended line with a portion of the Canadian quota taken as bycatch in other highly migratory species fisheries (e.g., swordfish longline). The U.S. bluefin tuna fishery is managed on the federal level by NOAA Fisheries with quotas allocated to five categories of fish harvesters: purse seine, harpoon, angling, longline as bycatch in other highly migratory species fisheries, and catch in trap nets.

Bluefin tuna is a species that may increase in the Gulf of Maine with increasing ocean temperatures. Conversations with fish harvesters suggest that the center of the bluefin tuna fishery was in the mid-Atlantic region in the past and appears to have shifted northward to the Gulf of Maine. Bluefin tuna catch in the Gulf of Maine varies widely (Figure 9) with availability of tuna and quotas set by ICCAT.

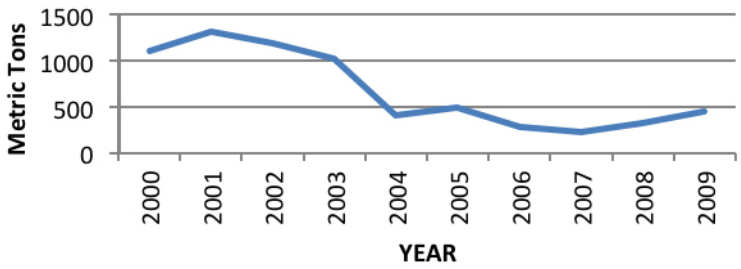


Figure 9: Gulf of Maine bluefish tuna landings, 2000-2009 (Source: DFO landings data; ACCSP landings data).

3.2 ECONOMIC VALUE OF FISHERIES

Gulf of Maine commercial fisheries contribute to the region's economy through activity within individual fisheries, the cumulative value of landed species in the region, and the economic output of the entire industry. The combined seafood industry of Massachusetts, New Hampshire, and Maine generated $10.3 billion in sales impacts in 2011 (NMFS 2012b). The economic output of New Brunswick's Bay of Fundy commercial fisheries and seafood processing sectors was $474 million in 2008 (Gardner and MacAskill 2010), while a significant portion of Nova Scotia's total of $1.5 billion for the same sectors in 2006 came from the Gulf of Maine/Bay of Fundy (Gardner et al. 2009).[5]

[5] Nova Scotia's total includes all ocean areas around Nova Scotia, not just the Gulf of Maine/Bay of Fundy. The total for Massachusetts, New Hampshire and Maine includes areas south of the Gulf of Maine.

Market Price for Selected Species

Market price is an indicator of the value of a particular species at point of first sale. Figures 10 and 11 show the gradual increase in the market price for selected species from 1970 to 2011. Atlantic herring is shown in a different figure because of the low value per pound relative to the other species listed in Figure 10. These figures are not adjusted for measures of inflation such as the consumer price index (CPI). Lobster prices in 2012 adjusted for CPI are lower than those in 1960 (Dayton and Sun 2012).

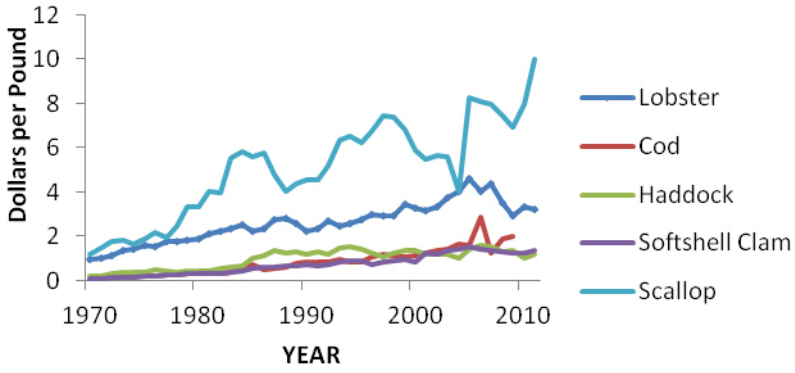


Figure 10: Price for selected Gulf of Maine fisheries, 1970-2011 (Source: DFO landings data; MEDMR landings data).

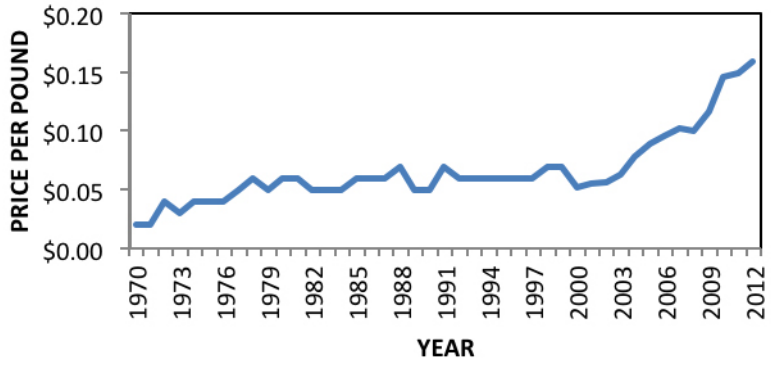


Figure 11: Atlantic herring price per pound, 1970-2012 (Source: DFO landings data; MEDMR landings data).

Total Landed Value

The overall value of landings (the sum of values at point of first sale) provides another indicator of the economic value of Gulf of Maine commercial fisheries. Figure 12 shows total Gulf of Maine landed value varying from $900 million to $1.3 billion between 2000 and 2010, with a peak in 2006. A longer term look at the total value of fisheries in Maine from 1970 through 2012 shows a long-term

increase in the commercial fisheries value (Figure 13); a significant portion of this increase is due to higher lobster landings. These numbers are not adjusted for inflation. The Canada-U.S. exchange rate plays a significant role in determining economic returns on the Canadian side of the border.

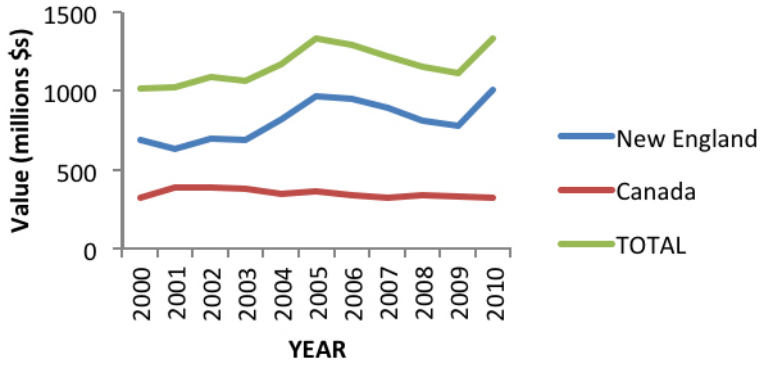


Figure 12: Total value of Gulf of Maine commercial species, 2000-2010 (Source: NMFS 2012b; DFO landings data; includes Gulf of Maine and all Massachusetts landings including south of Cape Cod).

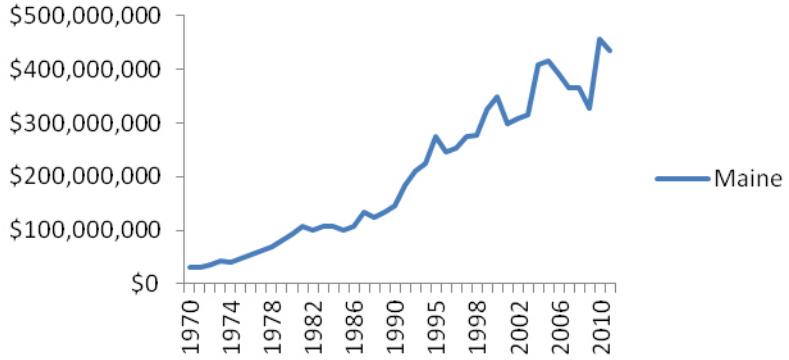


Figure 13: Total commercial fisheries value for State of Maine, 1970 to 2012 (Source: MEDMR landings data).

3.3 EMPLOYMENT IN FISHERIES AND RELATED INDUSTRIES

Employment in commercial fisheries and related fields is important economically and culturally in the Gulf of Maine region, supporting over 21,000 harvester and 1,100 processing sector jobs in the region. An important component of the role of commercial fisheries and processing in the region's economy is where these activities take place. Many of the commercial fishing and processing jobs occur in parts of the region that are geographically isolated and dependent on the natural resource based economy. Commercial fishing brings work and income to communities dispersed along the length of the Gulf of Maine, both in direct jobs and indirect supply services.

The number of people licensed as fish harvesters has declined over time for many reasons, including limited entry programs, consolidations within fleets, changing fish availability, and alternative employment opportunities. Table 2 shows license trends over time for Gulf of Maine jurisdictions. Reductions in license numbers over time are likely the result of a combination of limited entry systems, management changes, and attrition.

Fish processing plants are an integral part of the marine fisheries economy. The number of processing plants in the Gulf of Maine has varied over time as shown in Table 3. Changes in processing capacity have varied due to world markets, labor and raw material prices, and changes in automation and efficiencies.

Table 2: Number of commercial fishing licenses/license holders issued in Gulf of Maine jurisdictions by year (Source: NMFS 2010; 2012b; DFO 2013d; state data). Data for Nova Scotia, New Brunswick and Maine show the number of license holders. Data for New Hampshire and Massachusetts show the number of licenses.

	1985	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N.S.[a]	11,780	14,465	11,610	11,659	5,202	5,196	5,287	5,265	5,199	5,130	5,043	5,111
N.B.[a]	1,612	2,057	1,745	1,734	1,019	988	957	918	878	823	791	787
Maine	6,942	12,098	11,037	10,897	10,822	10,912	10,496	10,272	10,055	9,667	9,543	9,325
N.H.	[b]	[b]	608	635	697	685	691	693	654	630	634	609
Mass.	[b]	[b]	9,194	9,228	9,440	9,298	8,689	8,381	7,925	7,778	7,686	8,115

[a] License data for DFO Maritimes administrative region, which includes both the Scotian Shelf and Bay of Fundy/Gulf of Maine.
[b] Data not available.

Table 3: Fish processing plants in Gulf of Maine region (Source: Gardner Pinfold 2007; Gardner and Macaskill 2010; NMFS 2012b; NS Department of Fisheries and Aquaculture data; NB Department of Agriculture, Aquaculture, and Fisheries data).[a]

YEAR	2003	2004	2005	2006	2007	2008	2009	2010
Nova Scotia[b]	292	285	279	285	276	256	253	249
New Brunswick	132	129	143	139	134	126	122[c]	122[c]
Maine[d]	97	85	79	81	92	93	88	91
New Hampshire[d]	18	14	14	14	12	7	8	8
Massachusetts[d]	78	78	78	83	76	70	68	70

[a] Includes all processing plants in provinces and states, including areas outside the Gulf of Maine.
[b] Nova Scotia figures are the number of licenses. Not all licensed plants may be in operation.
[c] New Brunswick processing licenses changed in 2010 to primary (raw product from fishermen) and secondary (value added processing); these totals include both types of licensed processing plants.
[d] Includes employer establishments and non-employer firms (such as sole proprietorships).

3.4 FIRST NATION/ABORIGINAL COMMERCIAL FISHERIES

In Canada, Aboriginal groups participate in commercial fisheries for various species in Gulf of Maine waters. Through negotiation, Canada has provided Aboriginal groups with commercial fishing licenses which are communal licenses held by the Aboriginal group. The involvement of Aboriginal groups in the overall management of the fisheries is by way of their participation in specific advisory committees for each fishery.

In the United States, First Nation fisheries are addressed at the federal and state levels. The U.S. federal government has a nation-to-nation relationship with tribes administered by the Department of Interior. The Department of Interior and Department of Commerce have committed to increased communication with tribes on shared interests regarding marine fisheries. Gulf of Maine states also interact with local tribes. In Massachusetts, tribal access to local shellfish fisheries and other limited access fisheries has been discussed intermittently. In Maine, the Penobscot Indian Nation and the State of Maine collaborate on anadromous fish restoration. For example, the Penobscot River Restoration Project (PRRT 2013) involves removing dams from the Penobscot River to improve diadromous fish passage and to maintain hydropower production levels. In Maine, the Passamaquoddy Tribe issues commercial fishing licenses. The number of tribal lobster and urchin licenses is capped in these limited entry fisheries. There are ongoing discussions about the elver fishery and about access to commercial fisheries by other tribes.

3.5 IMPORTANT FISHING PORTS/PROCESSING CENTERS

The largest fishing ports in the Gulf of Maine region are those that have working waterfronts, the capacity to handle large volumes of fishery products, and the infrastructure to berth, maintain, repair, and provision fishing vessels. There are also many ports in the Gulf of Maine that are smaller in size and capacity but are important to the region's commercial fisheries. The U.S. portion of the Gulf of Maine has 29 fishing communities in Massachusetts, 7 in New Hampshire, and 50 in Maine (NMFS 2009); 4 of these communities are listed in the top 50 landings ports in the United States: Gloucester and Provincetown-Chatham in Massachusetts, and Portland and Stonington in Maine (NMFS 2010). In Canada, ports are labeled as core fishing harbors, which are managed by harbor authorities, and non-core fishing harbors, which are not managed by harbor authorities (DFO 2012b). In the Gulf of Maine region, there are 26 core harbors and 7 non-core harbors in New Brunswick and 49 core harbors and 5 non-core harbors in Nova Scotia. The U.S. and Canadian numbers are not exactly comparable because "fishing communities" and "fishing harbors" are defined differently, but the overall number and geographic distribution throughout the Gulf of Maine indicates the importance of small and large working waterfront locations and facilities to the region.

Equally important to the commercial fishing industry is processing capacity. Fish processing in New Brunswick was valued at $399 million in 2008 (Gardner and MacAskill 2010). In the Bay of Fundy region, 34-40 processors employing 1,670-2,100 employees operated from 2003-2008. Nova Scotia had 182 operating processing plants in 2006, a decline of about 50 percent since the 1980s (Gardner Pinfold 2007). In the U.S. portion of the Gulf of Maine, 163-190 processing plants operated from 2000 to 2010 (NMFS 2012b).

4. Impacts

4.1 HEALTH OF ECOSYSTEMS

Impacts on Biodiversity, Productivity, and Habitat

The health of fishery resources in the Gulf of Maine and economic well-being of fish harvesters and fishing communities depend on the overall health of the ecosystem. The health of the Gulf of Maine is impacted by many factors including impacts of commercial fishing on biodiversity, dominant fisheries, productivity, and habitat.

The biological communities in the Gulf of Maine have never been static, with changes in the distribution and relative abundance of various species over time. Currently, the Gulf of Maine ecosystem is being impacted by relative changes in dominant fisheries (e.g., cod, dogfish, and lobster) and an increasing number of invasive species. Some fish harvesters believe that cod populations cannot recover while lobster and dogfish abundance is high because they think that the latter two fisheries exert a strong influence on cod productivity. Another factor hypothesized to impact the Gulf of Maine ecosystem is the pattern of commercial fisheries. Concentration of fishing on lower trophic levels may lead to fishery declines and ecosystem impacts (Pauly et al. 1998; Steneck et al. 2004). The nature and extent of fishery impacts on trophic-level dynamics (i.e., changes in the relative abundance of various components of the food web) is controversial and under debate (Hilborn 2010) but the potential effects on Gulf of Maine fisheries warrant ongoing attention. Finally, climate change will also affect Gulf of Maine biological communities (see Climate Change and its Impacts on Ecosystems, Habitats and Biota theme paper). For example, the relative abundance of cod is expected to decrease as fish move to deeper waters and higher latitudes in increasing temperature (Cheung et al. 2008).

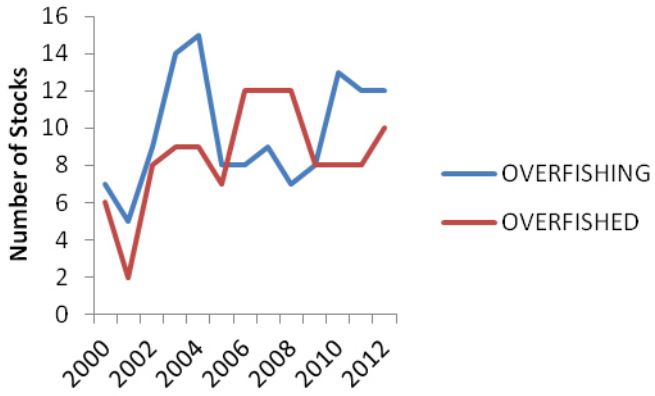
Fish harvesters, scientists, and fishery managers are increasingly discussing reduced fishery productivity as a significant factor in the Gulf of Maine. Annual assessments of shared cod, haddock, and yellowtail flounder stocks indicate that all three species have reduced sizes and cod and yellowtail flounder currently exhibit lower productivity than in the past (TRAC 2012a; 2012b; 2012c). Fishing may impact fish productivity through genetic changes (Smith 1994) and selection for smaller fish, early maturation, and changes in migration patterns (Rose et al. 2008).

Fishing activity can also impact habitat in the Gulf of Maine by direct disturbance of the bottom (Kaiser et al. 2003) and by unretrieved or lost fishing gear. Impacts of bottom disturbance include degraded habitat structure, removal of emergent seabed organisms, attraction of predators to disturbed areas, sorting and resuspension of bottom sediments, and exposure of buried contaminants. Lost or unretrieved fishing gear can continue to catch target and non-target species, impact benthic habitat, and introduce synthetic material in the marine environment (Macfadyen et al. 2009).

Impacts on Fish Stocks

Two indicators of fish stock health used in fishery management are whether a stock is above fishing mortality reference points (called overfishing in the United States and above the removal reference in Canada) or below certain stock status reference points (called being overfished in the United States and below limit reference point in Canada). In the United States, the National Marine Fishery Service reports annually to the Congress on the status of U.S. fisheries (NMFS 2013a). Figure 14 shows the number of overfished stocks and the number of stocks where overfishing is occurring from 2000 to 2012.

Figure 14: Number of U.S. Gulf of Maine fisheries that are overfished or exhibit overfishing (Source: NMFS annual reports to Congress on status of fisheries).



In Canadian fisheries management, the harvest is guided by the status of a stock in relation to upper and limit reference points. The limit reference point (LRP) is the point below which serious harm is occurring to the stock, and stocks below the LRP are considered to be in a "critical" state. In 2012, two Gulf of Maine stocks were below their LRP: 4X5Y cod and 5Zjm cod. In addition, two Gulf of Maine stocks were fished above their removal reference: 5Zjm cod and 5Zhjm yellowtail flounder. While the harvest strategy for both 5Zjm cod and 5Zhjm yellowtail flounder is to maintain a low to neutral risk of exceeding the removal reference, fishing mortality has consistently been above, as reported in the Transboundary Status Report series. This may be attributed, at least in part, to weaknesses in the assessment model (S. Quigley, Fisheries Management, DFO Maritimes, pers. comm.).

The increase in these trends over time in the U.S. results both from changing stock status and changes in biological reference points, as well as increases in the number of stocks with quantitative assessments. Consequently, the upward trend in the number of stocks that are overfished or in which overfishing is occurring may be misleading. The multiple stocks in the groundfish fishery can also result in some species or stock components being overfished while others are not being overfished. Regardless of these data inadequacies, the increasing trend in this indicator demonstrates the ongoing need for sustainable fishery management and research into factors that influence the health of fish stocks in the Gulf of Maine.

4.2 SOCIAL AND CULTURAL WELL-BEING

In many ways, the social and cultural health of Gulf of Maine communities is linked to commercial fisheries. Changes in the fisheries can affect employment opportunities, income, secondary economic benefits, feelings of connection to the ocean, and sense of community. The decline of the groundfish fishery illustrates this phenomenon as individuals, families, communities, and governments try to grapple with vastly changed conditions. Conversely, the growth in lobster landings has been the catalyst for much economic growth in fishing families and communities. However, this comes at a time when rising costs, changing world markets, increased regulations, and other factors make people and communities that rely on lobster concerned about the sustainability and economic future of this fishery (Steneck et al. 2011).

Recent changes from open to limited access fisheries has led to some concerns from fishing communities in the U.S. portion of the Gulf of Maine. Previously, fish harvesters would switch from one fishery to another in response to changing conditions in a fishery, such as relative abundance or market demand. While this change is seen to constrain the ability to switch among fisheries, it does provide increased stability for those participating in the fishery. Limited access fisheries have been in place much longer in the Canadian fisheries in the Gulf of Maine and these have been a generally accepted management measure.

An important demographic trend in commercial fisheries is the increasing average age of fish harvesters (Mount Auburn 2009; Dayton and Sun 2012). Entry by young people into the region's commercial fisheries is impacted by many factors, including limited access programs and high capital costs. Additionally, modern fishing equipment makes it easier for aging fish harvesters to remain in commercial fishing. Ultimately, to maintain commercial fishing as a strong and viable sector in Gulf of Maine communities, processes must allow for new entrants to acquire permits such as through lotteries, entry/exit ratios, and permit buying. Increased population and development in coastal areas also impacts the region's commercial fisheries through reduced availability of working waterfront and increased values of coastal properties (see Coastal Land Use and Development theme paper).

5. Actions and Responses

Gulf of Maine jurisdictions and interests take many actions in response to the threats and pressures being exerted on marine fisheries resources. This includes legislative and management action by federal governments, provincial governments, and state governments; bilateral management actions; shifts toward ecosystem based management; marketing and certification programs; and monitoring fisheries and the marine environment. Examples of actions and responses are listed below.

5.1 LEGISLATION

Governments in the Gulf of Maine regulate marine fisheries at national, provincial or state, and, in limited cases, local levels. Some fisheries are highly regulated, such as groundfish, scallops, and herring. Others have far fewer regulations because they are smaller fisheries geographically or economically, or because they simply have not received attention by fishery management authorities. Examples of less regulated fisheries include marine worms, hagfish, and sea urchin. The risk for fisheries with few regulations is that fishing effort will deplete the stock, as happened in the Gulf of Maine sea urchin fishery (Taylor 2004).

In Canada, marine fisheries are managed through the federal *Fisheries Act*, which applies to all fisheries and fishing areas. Canada also manages its oceans through the *Oceans Act*, which is a comprehensive approach to ocean management founded on sustainable development, integrated management, and the precautionary approach. Additionally, marine species at risk in Canada are protected through the *Species at Risk Act*, which protects marine mammals, fish, and mollusks and their habitats through a listing and management process. The provinces and territories manage most shoreside components of commercial fisheries.

In the United States, marine fisheries are managed by the states from the shore to three miles offshore and by the federal government from three miles offshore to the seaward limit of the Exclusive Economic Zone. Fisheries in federal waters are managed through the *Magnuson-Stevens Fishery Conservation and Management Act* for sustainable use and protection of fish habitat. Fisheries in state water are managed by regulations and statutes in individual states and by the Atlantic States Marine Fisheries Commission (ASMFC) for interjurisdictional fisheries through the *Atlantic Coastal Fisheries Cooperative Management Act* (ACFCMA). The federal and state fishery management systems use cooperative and sometimes joint planning to coordinate activities between state and federal waters.

Species at risk of extinction are protected and managed through the Endangered Species Act Regulations in the United States. Species at risk are those species for which there are concerns about population status and trends. Species at risk or

species of concern lists for marine species are maintained by NOAA Fisheries (NMFS 2013b) and by states. Actions to protect at-risk species can impact commercial fisheries. For example, regulations to protect Atlantic and shortnose sturgeon also affect the gillnet fishery. The United States protects and manages marine mammals, whether or not legally endangered, through *the Marine Mammal Protection Act* (MMPA), which mandates takes (direct and indirect impacts on marine mammals) be managed with the goal of no bycatch or incidental mortality. The MMPA can impact commercial fisheries in the Gulf of Maine region through gear restrictions, time and area closures, and requirements for equipment that deters marine mammals.

5.2 MANAGEMENT

In Canada, fisheries are managed by Fisheries and Oceans Canada using a variety of tools, including legislation, regulation, fisheries management plans, conservation harvesting plans, and license conditions. In the United States, fisheries are managed by the National Marine Fisheries Service and state fisheries agencies. As in Canada, there are a suite of management tools used.

Management actions can be taken to achieve a variety of biological and/or social objectives. To meet stock sustainability goals, fisheries managers are increasingly using targets and reference points for stocks to inform management. They take management actions based on the size of the stock relative to these reference points, as well as other biological and fisheries factors and trends in a particular fishery or stock.

Transboundary Stocks

A number of commercial fish species fall under the jurisdiction of both Canada and the United States because the fish stocks occur on both sides of the international boundary. Therefore, the management actions taken in one country can affect the fisheries in the other country. Joint assessment is done through the Transboundary Resources Assessment Committee (TRAC) (DFO 2008a). Joint quotas are established through the Transboundary Management Guidance Committee (TMGC) (DFO 2008b), which meets annually to consider TRAC assessment advice and to recommend quotas for the shared stocks under TMGC purview. The TMGC subsequently makes recommendations to the management authorities in Canada and the United States for final approval. The TMGC process has become more difficult over time because of the different legal processes used by Canada and the United States in establishing quotas. Canadian laws and regulations allow some flexibility in quota setting, whereas U.S. laws and regulations specify a maximum allowable catch for different stocks based on *Magnuson-Stevens Act* rebuilding requirements. These differences in the Canadian and U.S. processes have occasionally resulted in difficulties in reaching a final agreement between the countries. In response to this situation, the U.S. law was changed to

TRAC assessment stocks[a]

- Georges Bank Yellowtail Flounder
- Eastern Georges Bank Cod
- Eastern Georges Bank Haddock
- Atlantic Mackerel
- Spiny Dogfish
- Georges Bank / Gulf of Maine Herring Stock Complex

[a] Not all TRAC stocks are regularly assessed

TMGC stocks

- Georges Bank Yellowtail Flounder
- Eastern Georges Bank Cod
- Eastern Georges Bank Haddock

allow the United States-Canada Transboundary Resource Sharing Understanding to be considered an international agreement which allows some flexibility in setting the shared quotas through the TMGC process. This will provide some flexibility in setting quotas for the three shared stocks (GovTrackUS 2010).

Ecosystem-based Fisheries Management

Fisheries have traditionally been managed using a single species approach, such as herring regulations to address herring issues and lobster regulations to address lobster issues. A few fisheries, such as the scallop fishery, have cross-fishery provisions, which in this case minimize groundfish bycatch in the scallop fishery. Scientists and fishery managers increasingly recognize the need for management planning and actions that consider connections among many fisheries and with biological, oceanographic, and habitat components of an ecosystem. Canada and the United States have acknowledged the need to incorporate more and better ecosystem planning in marine fisheries (Pres. Exec. Order 2010; DFO 2013e).

The shift to ecosystem-based fishery management will take time, as multispecies stock assessments are developed and tested, multispecies management approaches are developed, and ecosystem-based concepts are understood and accepted by fishery management stakeholders.

5.3 INDUSTRY INITIATIVES/ECO-CERTIFICATION AND VERIFICATION

Product certification or verification programs allow producers, industry groups, governments, and consumers to determine if a product meets certain standards. Fisheries certification is the setting of standards for sustainability with assessments of individual fisheries being conducted by third parties, as is done through

the Marine Stewardship Council (MSC) and the Gulf of Maine Research Institute's (GMRI) Responsibly Harvested Fisheries programs. For fisheries, certification usually focuses on whether fisheries are conducted with some degree of biological and ecological sustainability and with product traceability through the seafood supply chain. These certifications are designed to allow consumers to make informed choices about their seafood purchases and provide fisheries, dealers, and processors with a marketing advantage when promoting their products. As more consumers look for these labels, interest in fisheries certification processes is increasing among all sectors of the industry.

Many fishery certification or verification programs exist (Parkes et al. 2009), including those of the MSC, Monterey Aquarium, and GMRI. The certification programs of the MSC and GMRI include some Gulf of Maine fisheries (see boxes).

Certification or verification of fisheries is a recent addition to the tools used by Gulf of Maine commercial fish harvesters, dealers, processors, and governments working to manage and promote sustainable fisheries. The trend toward fisheries certification and verification will likely continue to increase in the region because of the globalization of seafood and consumer demand for sustainably caught fish.

Gulf of Maine Fisheries in Marine Stewardship Council program

Certified

- Atlantic Deep Sea Red Crab[a]
- Scotian Shelf Prawn[b]
- Spiny Dogfish[a]
- Eastern Canada Sea Scallop (offshore)[b]
- Offshore Lobster[b]
- Maine Lobster[a]
- Canada Scotia-Fundy Haddock[b]
- Northwest Atlantic Swordfish Longline[b]
- Northwest Atlantic Swordfish Harpoon[b]
- North Atlantic Swordfish[a]
- Canada Atlantic Halibut[b]

Undergoing Certification

- Full Bay Scallop Association[b]
- U.S. Atlantic Scallop[a]

[a] U.S. fishery
[b] Canadian fishery

Fisheries in Gulf of Maine Research Institute's Responsibly Harvested Fisheries program

- American Lobster[b]
- Atlantic Mackerel[b]
- Atlantic Cod[b]
- Atlantic Pollock[b]
- Atlantic Sea Scallops[b]
- Atlantic Spiny Dogfish[a]
- Haddock[b]
- Northern Shrimp[b]
- Redfish[b]
- Whiting (silver hake)[b]

[a] U.S. fishery
[b] U.S. and Canadian fisheries

5.4 RESEARCH AND MONITORING

Research and monitoring are necessary components in the sustainable management of Gulf of Maine commercial fisheries. Federal governments, state and provincial governments, and university and private research programs all play important roles in this arena. In Canada, Fisheries and Oceans Canada has a central, legislatively mandated responsibility for fisheries research and monitoring. In the United States, NOAA Fisheries, through their Northeast Regional Office and Northeast Fisheries Science Center, conducts much research and monitoring in the Gulf of Maine. State marine fisheries agencies have a complementary role in research and monitoring, concentrating on species in state-managed waters. Private research institutions and non-government organizations also have programs that are focused on specific areas of interest.

There are many monitoring and research programs throughout the Gulf of Maine ranging from local, single species efforts to large scale, comprehensive surveys. Research trawl surveys are conducted regularly in the Gulf of Maine by both DFO and NOAA Fisheries to assess the health of fish stocks in the region. In addition, inshore trawl surveys are conducted in state waters from Maine through North Carolina under the Northeast Area Monitoring and Assessment Program (NEAMAP) (NMFS 2013c). Scallop resources are monitored in Canada and the United States using dredge surveys as well as by drop camera surveys in the United States (SMAST 2013). Many smaller scale monitoring programs also take place in various portions of the Gulf of Maine region.

6. Indicator Summary

INDICATOR	DPSIR FRAMEWORK	STATUS	TREND
Market demand	Driving Force	Good—Demand for Gulf of Maine seafood products is strong.	Improving—Growing demand ensures markets for fisheries products caught in the Gulf of Maine.
Ocean acidification	Pressure	Fair—Evidence of increasing acidification.	Worsening—Increased acidification threatens Gulf of Maine species.
Number of invasive species	Pressure	Fair—Evidence of invasive species (e.g., green crabs, tunicates) affecting commercial marine species.	Worsening—The number of species introduced to the region continues to increase.
Number of processing plants	State	Fair—Seafood processing continues to occur in the region, although at a reduced scale from 20 years ago.	Worsening—Decreasing number of plants in region reflects world market pressures, processing offshore, economics of fisheries, and automation.
Landings in major fisheries	State	Fair—While landings in the invertebrate fisheries have increased or stayed relatively constant, traditionally important groundfish and herring landings are low relative to historic values.	No trend—Trends vary from fishery to fishery.
Total value of fisheries	State	Good—Overall value of fisheries continues to be an important contributor to the economy of the Gulf of Maine.	No trend—Upward trend in total value but has not kept pace with inflation.
Overfished fisheries	Impact	Fair—Many fisheries above fishing mortality targets, below biomass targets.	Improving—Increasing number of fisheries trending toward reference points or within biological limits.
Certified fisheries	Response	Fair—Increasing number of certified fisheries, selection of certification processes.	Improving—Interest is increasing the number of certified fisheries.
Reference points established for major fisheries	Response	Good—Reference points have been established for most major fisheries in the Gulf of Maine.	Improving—Reference points continue to be refined for major fisheries and established for smaller fisheries.

Categories for Status: Unknown, Poor, Fair, Good.
Categories for Trend: Unknown, No trend, Worsening, Improving.

7. References

AP (Associated Press). 2012. New Brunswick union reaches pact on Maine lobsters. http://www.bostonglobe.com/metro/2012/08/11/new-brunswick-union-reaches-pact-maine-lobsters-protest-ends/sFeBtnwOSAWbrLfnc0IFqM/story.html (accessed January 2013)

ASMFC (Atlantic States Marine Fisheries Commission). 1996. A review of the population dynamics of the American lobster in the Northeast. ASMFC Special Report 61. Arlington VA: Atlantic States Marine Fisheries Commission. 48 pp.

ASMFC. 1997. Amendment 3 to the Interstate Fishery Management Plan for lobster. Arlington VA: Atlantic States Marine Fisheries Commission. 36 pp.

ASMFC. 2006. Amendment 2 to the Interstate Fishery Management Plan For Atlantic Herring. Arlington VA: Atlantic States Marine Fisheries Commission. 97 pp.

ASMFC. 2009. American Lobster Stock Assessment Report for Peer Review. Stock Assessment Report No. 09-01 (Supplement). Arlington VA: Atlantic States Marine Fisheries Commission. 298 pp.

Bank of Canada. 2013. Monthly and annual average exchange rates. http://www.bankofcanada.ca/rates/exchange/exchange-rates-in-pdf (accessed March 2013).

Beal B. 2000. Predation and soft-shell clams. http://www.maine.gov/dmr/research/soft_shell_clams.htm#attach.%20D (accessed January 2013).

Brodziak J and Traver M. 2006. Status of fishery resources off the Northeastern US: Haddock. http://www.nefsc.noaa.gov/sos/spsyn/pg/haddock/ (accessed January 2013).

CBC (Canadian Broadcasting Corporation). 2012. Lobster fishermen block N.B. Processing Plant. http://www.cbc.ca/news/canada/new-brunswick/story/2012/08/02/nb-lobster-fishermen-protest-shediac.html (accessed January 2013).

Cheung WL, Lang WWY, Sarmiento JL, Kearney K, and Pauly D. 2008. Projecting global marine biodiversity impacts under climate change. Fish and Fisheries 2009(10): 235-257.

Collette B and Klein-MacPhee G. 2002. Bigelow and Schroeders's fishes of the Gulf of Maine. 3rd ed. Washingon DC: Smithsonian Institution Press. 746 pp.

Curran K and Azetsu-Scott K. 2012. Ocean acidification. State of the Scotian Shelf Report. http://coinatlantic.ca/docs/ocean-acidification.pdf (accessed April 2013).

Dayton A and Sun J. 2012. An independent evaluation of the Maine limited entry licensing system for lobster and crab. Portland, Maine: Gulf of Maine Research Institute. 82 pp.

DFO (Department of Fisheries and Oceans). 2000. 2000 Scotia-Fundy Offshore Scallop Integrated Fisheries Management Plan: Maritimes Region. http://www2.mar.dfo-mpo.gc.ca/fisheries/res/imp/2000Offscal.htm (accessed April 2013).

DFO 2003. Groundfish Integrated Fisheries Management Plan, Scotia-Fundy Fisheries, Maritimes Region, April 1, 2000 – March 31, 2002. http://www2.mar.dfo-mpo.gc.ca/fisheries/res/imp/2000grndfish.htm (accessed February 2013).

DFO. 2004. Herring management—Martimes Region. http://www.dfo-mpo.gc.ca/media/infocus-alaune/2004/20040325/sheet-feuillet2-eng.htm (accessed January 2013).

DFO. 2008a. Transboundary Resources Assessment Committee (TRAC). http://www2.mar.dfo-mpo.gc.ca/science/trac/TRAC.html (accessed January 2013).

DFO. 2008b. Transboundary Management Guidance Committee (TMGC). http://www2.mar.dfo-mpo.gc.ca/science/tmgc/TMGC-e.html (accessed January 2013).

DFO. 2009. Underwater world: Green crab. http://www.dfo-mpo.gc.ca/Science/publications/uww-msm/articles/greencrab-crabevert-eng.html (accessed January 2013).

DFO. 2011. Integrated Fishery Management Plan (Summary) Lobster Fishing Areas 27 - 38 Scotia-Fundy Sector Maritimes Region 2011. http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/maritimes/insholob-2011-eng.htm (accessed January 2013).

DFO. 2012a. Assessment of Northern Shrimp on the Eastern Scotian Shelf (SFAs 13-15). DFO Canadian Science Advisory Secretariat Science Advisory Report 2012/001.

DFO. 2012b. List of Harbours and Harbour Activities. http://www.dfo-mpo.gc.ca/sch-ppb/list-liste-eng.htm (accessed February 2013).

DFO. 2013a. Canadian fisheries statistics: International trade. http://www.dfo-mpo.gc.ca/stats/trade-commerce/can/export/xmkt12-eng.htm (accessed February 2013).

DFO. 2013b. Atlantic cod. http://www.dfo-mpo.gc.ca/science/publications/uww-msm/articles/atlanticcod-morueatlantique-eng.htm (accessed March 2013).

DFO. 2013c. Scallop Fishing Area 28 (Bay of Fundy). www.dfo-mpo.gc.ca/decisions/fm-2012-gp/atl-041-eng.htm (accessed April 2013).

DFO. 2013d. Commercial fisheries: Licences. http://www.dfo-mpo.gc.ca/stats/commercial/licences-permis/licences-permis-atl-eng.htm (accessed March 2013).

DFO. 2013e. Sustainable Fisheries Framework. http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/overview-cadre-eng.htm (accessed April 2013).

Fogarty M, Incze L, Hayhoe K, Mountain D and Manning J. 2008. Potential climate change impacts on Atlantic cod (*Gadus morhua*) off the northeastern USA. Mitigation and Adaptation Strategies for Global Change 13: 453–466

Fogarty M, Incze L, Wahle R, Mountain D, Robinson A, Pershing A, Hayhoe K, Richards A and Manning J. 2007. Potential climate change impacts on marine resources in the Northeastern United States. Northeast Climate Impacts Assessment (NECIA) Techical Paper. http://www.northeastclimateimpacts.org/#Papers (accessed February 2013.)

FRCC (Fishery Resource Council of Canada). 2011. Toward recovered and sustainable groundfish fisheries in Eastern Canada. http://publications.gc.ca/collections/collection_2011/mpo-dfo/Fs158-4-2011-eng.pdf (accessed February 2013).

Frumhoff P, McCarthy J, Melillo J, Moser S, and Wuebbles D. 2007. Confronting climate change in the U.S. Northeast: Science, impacts, and solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS). 146 pp.

Gardner M and MacAskill G. 2010. Economic impact of the New Brunswick ocean sector 2003–2008. http://www.gnb.ca/9999/publications/ocean.pdf 40 pp (accessed January 2013).

Gardner M, MacAskill G and Debow C. 2009. Economic impacts of the Nova Scotia ocean sector 2002–2006. 63 pp. http://www.gov.ns.ca/econ/publications/oceanindustries/docs/NS_Ocean_Sector_Report_2002-2006.pdf (accessed March 2013).

Gardner Pinfold. 2007. Nova Scotia Seafood Processing Sector: State of the Industry and Competitiveness Assessment. 57 pp. http://www.gov.ns.ca/fish/marketing/reports/seafoodreport.pdf (accessed March 2013).

GovTrackUS. 2010. H.R. 81 (111th) International Fisheries Agreement Clarification Act. http://www.govtrack.us/congress/bills/111/hr81 (accessed April 2013).

Grabowski J, Clesceri E, Baukus A, Gaudette J, Weber M and Yund PO. 2010. Use of herring bait to farm lobsters in the Gulf of Maine. PLoS ONE 5(4): e10188. doi:10.1371/journal.pone.0010188 (accessed February 2013).

Hart D. 2006. Status of the fishery resources off the Northeastern US, Atlantic: Sea Scallop. http://www.nefsc.noaa.gov/sos/spsyn/iv/scallop (accessed January 2013).

Hilborn R. 2010. Apocalypse forestalled: Why all the world's fisheries are not collapsing. http://www.atsea.org/doc/Hilborn%202010%20Science%20Chronicles%202010-11-1.pdf pp 5-9 (accessed February 2013).

Kaiser MJ, Collie JS, Hall SJ, Jennings S and Poiner IR. 2003. In: M Sinclair and G Valdimarsson (eds), Responsible fisheries in the marine ecosystem. Rome, Italy and Wallingford, UK: FAO and CABI Publishing. pp. 197–216.

Kitts A, Bing-Sawyer E, McPherson M, Olson J and Walden J. 2011. Report for Fishing Year 2010 on the Performance of the Northeast Multispecies (Groundfish) Fishery (May 2010 – April 2011). NEFSC Ref. Doc. 11-12. 55 pp.

Kurlansky M. 1997. Cod: A biography of the fish that changed the world. New York: Walker and Company. 294 pp.

LeGresley M, Martin J, McCurdy P, Thorpe B and Chang B. 2008. Non-indigenous tunicate species in the Bay of Fundy, eastern Canada. ICES Journal of Marine Science 65: 770–774

Macfadyen G, Huntington T and Cappell R. 2009. Abandoned, lost or otherwise discarded fishing gear. UNEP Regional Seas Reports and Studies, No. 185; FAO Fisheries and Aquaculture Technical Paper, No. 523. Rome: UNEP/FAO. 115 pp. http://www.unep.org/regionalseas/marinelitter/publications/docs/Marine_Litter_Abandoned_Lost_Fishing_Gear.pdf (accessed April 2013).

Mayo R and O'Brien L. 2006. Status of fishery resources off the Northeastern US: Atlantic cod. http://www.nefsc.noaa.gov/sos/spsyn/pg/cod/ (accessed January 2013).

MEDMR (Maine Department of Marine Resources). 2012. 2012-2013 Scallop season and new management measures. http://www.maine.gov/dmr/rm/scallops/scallopmanagement.htm (accessed April 2013).

MEDMR. 2013. Historical Maine lobster landings. http://www.maine.gov/dmr/commercialfishing/documents/lobster.table_000.pdf (accessed January 2013).

NAMA (Northwest Atlantic Marine Alliance). 2012. List of community supported fisheries. http://namanet.org/csf (accessed January 2013).

NCCOS (National Centers for Coastal Ocean Sciences. 2011. Climate change and harmful algal blooms http://www.cop.noaa.gov/stressors/extremeevents/hab/current/CC_habs.aspx (accessed April 2013).

NEFMC (New England Fishery Management Council). 2007. Final amendment 1 to the Atlantic herring fishery management plan including a Final Supplemental Environmental Impact Statement (FSEIS) and Initial Regulatory Flexibility Analysis (IRFA). Newburyport, MA: New England Fishery Management Council.

NEFMC. 2009. Amendment 16 to the Northeast multispecies fishery management plan including a environmental impact statement and initial regulatory flexibility analysis. Newburyport, MA: New England Fishery Management Council. 905 pp.

NEFMC. 2013. Atlantic sea scallop fishery management plan. http://www.nefmc.org/scallops/index.html (accessed January 2013).

NEFSC (Northeast Fisheries Science Center). 2008. Assessment of 19 Northeast groundfish stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Department of Commerce, NOAA FIsheries, Northeast Fisheries Science Center Reference Document 08-15. 884 + xvii pp. http://nefsc.noaa.gov/publications/crd/crd0815/crd0815.pdf (accessed April 2013).

NEFSC. 2012. Assessment or data updates of 13 Northeast groundfish stocks through 2010. US Department of Commerce, Northeast Fisheries Science Center Reference Document 12-06. 789 pp. http://nefsc.noaa.gov/publications (accessed April 2013).

NMFS (National Marine Fisheries Service). 1999. Our Living Oceans. Report on the status of U.S. living marine resources, 1999. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-41. http://spo.nwr.noaa.gov/unit17.pdf (accessed February 2013).

NMFS. 2009. Fishing communities of the United States, 2006. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-F/SO-98. http://www.st.nmfs.noaa.gov/st5/publication/communities/CommunitiesReport_ALL.pdf (accessed February 2013).

NMFS. 2010. Fisheries economics of the U.S. http://www.st.nmfs.noaa.gov/st5/publication/fisheries_economics_2009.html (accessed January 2013).
NMFS. 2011. Fisheries of the United States 2010. Current Fisheries Statistics No. 2010. Washington, DC. 102 pp.
NMFS. 2012a. Secretary of Commerce declares disaster in Northeast groundfish fishery. http://www.nmfs.noaa.gov/mediacenter/2012/09/13_secretary_of_commerce_declares_disaster_in_northeast_groundfish_fishery.html (accessed April 2013).
NMFS. 2012b. Fisheries economics of the United States, 2011. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-118, 175p. https://www.st.nmfs.noaa.gov/st5/publication/index.html. (accessed April 2013).
NMFS. 2013a. Status of US Fisheries. http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm (accessed January 2013).
NMFS. 2013b. Proactive Conservation Programs: Species of Concern. http://www.nmfs.noaa.gov/pr/species/concern/ (accessed April 2013).
NMFS. 2013c. What is NEAMAP? http://www.nefsc.noaa.gov/groundfish/meetings/neamap.pdf (accessed March 2013).
NOAA (National Oceanic and Atmospheric Administration). 2013. Ocean Facts. http://oceanservice.noaa.gov/facts/population.html (accessed January 2013).
NSGLC (National Sea Grant Law Center). 2012. Starting and Maintaining Community Supported Fisheries (CSF) Programs. National Sea Grant Law Center. University, MS. 16pp.
OECD-FAO (Organization for Economic Co-operation and Development and UN Food and Agriculture Organization). 2012. OECD-FAO Agricultural Outlook 2012–2021. http://www.oecd.org/site/oecd-faoagriculturaloutlook/fish-oecd-faoagriculturaloutlook2012-2021.htm (accessed January 2013).
Ortman JM and Guarneri CE. 2012. United States population projections: 2000 to 2050. http://www.census.gov/population/projections/files/analytical-document09.pdf (accessed January 2013).
Overholz W. 2006. Status of fishery resources off the Northeastern US: Atlantic Herring. http://www.nefsc.noaa.gov/sos/spsyn/pp/herring (accessed January 2013).
Parkes G, Walmsey S, Cambridge T, Trumble R, Clarke S, Lamberts D, Souter D and White C. 2009. Review of fish sustainability information schemes. Kingston, RI: University of Rhode Island. 180 pp.
Pauly D, Christensen V, Dalsgaard J, Froese R, and Torres Jr F. 1998. Fishing down marine food webs. Science 279: 860-863.
PRRT (Penobscot River Restoration Trust). 2013. About the Project. http://www.penobscotriver.org/content/4003/the-project (accessed January 2013).
Pezzack D, Tremblay J, Claytor R, Frail C and Smith S. 2006. Stock status and indicators for the lobster fishery in Lobster Fishing Area 34. Canadian Science Advisory Secretariat Research Document 2006/010. 141 pp.
Pres. Executive Order. 2010. Stewardship of the oceans, our coasts, and the Great Lakes. Executive Order 13547. The White House, Washington, DC.
Revkin A. 2013. Bluefin Tuna Sold for Record $1.76 million in Tokyo "Auction." http://dotearth.blogs.nytimes.com/2013/01/04/bluefin-tuna-poised-for-new-record-sale-in-tokyo-auction-more-pressure-at-sea (accessed January 2013).
Richards A, Whitmore K, Fischer J, Hunter M, Waine M and Drew K. 2012. Assessment report for Gulf of Maine northern shrimp–2012. Washington DC: Atlantic States Marine Fisheries Commission. 81 pp.
Rose G, Bradbury I, deYoung B, Fudge S, Lawson G, Mello L, Rideout R, Robichaud D, Sherwood G, Snelgrove P and Windle M. 2008. Rebuilding Atlantic cod: Lessons from a spawning ground in coastal Newfoundland. In: G Kruse, K Drinkwater, J Ianelli, J Link, D Stram, V Wespedsad and D Woodby (eds), Resiliency of gadid stocks to fishing and climate change. Alaska Sea Grant Program. pp 197-220.
Schmitt C. 2011. Maine's climate future and Maine's seafood supply. University of Maine Climate News. http://umaine.edu/maineclimatenews/archives/spring-2011/ocean-acidification (accessed January 2013).
Serchuk FM, Grosslein MD, Lough RG, Mountain DG and O'Brien L. 1994. Fishery and environmental factors affecting trends and fluctuation in the Georges Bank and Gulf of Maine Atlantic cod stocks: an overview. ICES Marine Science Symposium 198: 77-109
SMAST (School of Marine Science and Technology, University of Massachusetts, Dartmouth). 2013. Marine Fisheries Field Research Group. http://webserver.smast.umassd.edu/lab_stokesbury (accessed April 2013).
Statistics Canada. 2008. Population Growth in Canada. http://www.statcan.gc.ca/pub/91-003-x/2007001/4129907-eng.htm (accessed February 2013).
Statistics Canada. 2013. Statistics Canada: latest estimates. http://www.statcan.gc.ca/start-debut-eng.html (accessed April 2013).
Steneck R, Hughes T, Cinner J, Adger W, Arnold S, Berkes F, Boudreau S, Brown K, Folke C, Gunderson L et al. 2011. Creation of a gilded trap by the high economic value of the Maine lobster fishery. Conservation Biology 25: 904-912.
Steneck RS, Vavrinec J, and Leland A. 2004. Accelerating trophic-level dysfunction in kelp forest ecosystems of the western North Atlantic. Ecosystems 7: 323-332.
Sosebee K, Traver M and Mayo R. 2006. Status of fishery resources off the Northeastern United States: Aggregate and resource and landings trends. http://www.nefsc.noaa.gov/sos/agtt (accessed January 2013).
Taylor P. 2004. Green Gold: Scientific findings for management of Maine's sea urchin fishery. Boothbay Harbor: Maine Department of Marine Resources. 33 pp.
Thayer P and Stahlnecker J. 2006. Non-native marine species in Maine. Report to Maine State Legislature, Marine Resources Committee and Natural Resources Committee. 22 pp.

TRAC (Transboundary Resources Assessment Committee). 2012a. Eastern Georges Bank haddock. TRAC Status Report 2012/03. http://www2.mar.dfo-mpo.gc.ca/science/trac/TSRs/TSR_2012_03_E.pdf 6pp. (accessed January 2013).
TRAC. 2012b. Eastern Georges Bank cod. TRAC Status Report 2012/02. http://www2.mar.dfo-mpo.gc.ca/science/trac/TSRs/TSR_2012_02_E_revised.pdf 11pp. (accessed January 2013).
TRAC. 2012c. Georges Bank Yellowtail Flounder. TRAC Status Report 2012/01. http://www2.mar.dfo-mpo.gc.ca/science/trac/TSRs/TSR_2012_01_E.pdf 8pp. (accessed January 2013).
United Nations. 2004. World Population to 2300. New York: UN Dept. of Economic and Social Affairs. http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf (accessed January 2013).
US Census. 2013. U.S. and world population clocks. http://www.census.gov/main/www/popclock.html (accessed April 2013).
Wang Y and O'Brien L. 2012. Assessment of Eastern Georges Bank Atlantic cod for 2012. TRAC Reference Document 2012/05. 83 pp.